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ACTIVE VIBRATION CONTROL ON A MEMBRANE SOLAR PANEL FOR NANOSATELLITES

Abstract

Membrane structures for space applications are extremely light appendages that extend from the main body of the satellite such as thin-film solar panels, membrane antennas, solar sails, etc, having the advantage of an extremely reduced mass and highly packed volume ratio. These structures allow a bigger payload to fit in the same total volume of the spacecraft. However, their thinness implies extremely high flexibility: increasing their physical dimensions, the first natural frequencies drop, approaching and intersecting the attitude control system (ACS) bandwidth. This poses serious concerns, since the ACS can excite and wrongly interpret vibration modes of the flexible structure, causing destabilizing feedback and threatening the stability of the spacecraft. For this reason, it is important to keep the membrane properly tensioned. In addition, also the frame structure that keeps the membrane tensioned can transmit disturbance torques to the body of the spacecraft and needs to be controlled. This paper focuses in particular on thin-film solar arrays for nanosatellites. Many researches have been carried out on this topic, but most of them have addressed the issue of keeping the membrane well tensioned and damping the vibrations at membrane level rather than the problem of reducing the low frequency vibrations possibly caused by this kind of large membrane structure to the central body of the satellite. In particular, this paper presents a case study on a membrane solar panel attached to two rollable and extendible booms, that are used to deploy it and keep it in tension. First, the design of the employed system is introduced. This design makes use of a small motor, so that the panel can be deployed and rolled up at any moment. The size of the motor and the required power is reduced using a worm drive system. Second, the active control system applied both on the booms and on the panel deployer is described. It makes use of smart materials that are able to counteract the vibrations and stabilize the system. Numerical simulation results are presented, and are followed by experimental tests outcome on a dummy solar array and satellite body that consolidate and validate the results of the numerical work.